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ANIMAL SCIENCE

The scientific literature on bats (chiroptera) in Brazil: a scientometric analysis from 1954 – 2018

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Abstract: Globally, bats are of interest in many studies, beyond their ecological or epidemiological relevance or even the ecomorphological diversity of species. In Brazil, most of the indexed studies on chiropterans date from 1954, with a slow and heterogeneous progress in the publication increasing. The aim of this study was to analyze the literature on bats in Brazil, identifying patterns, tendencies and knowledge gaps in the Brazilian federal states. We carried out a sistematyzed search on the online databases Clarivate Analytics Web of Science (WoS), Scientific Electronic Library Online (SciELO), PubMed and Scopus. We used the descriptive terms "Chiroptera" and "Brazil". Besides these bases, we included data from the manuscripts published in Chiroptera Neotropical. We obtained a total of 1,115 articles, which were analyzed and classified in 22 thematic categories based on the articles' approach. We observed that each Brazilian region and state had particularities in their knowledge panoramas of bats, not being possible to generalize conditions for each federal region. Even though the increasing in the number of articles by categories, we encourage that every approach keep being developded, once no thematic could had been considered enough explored till the moment.

Key words: Chiropterofauna, mastozoology, science, conservation.

INTRODUCTION

Bats started to be known in Brazil since the first naturalist expeditions, between the 16th and 19th centuries (Von Pelzeln 1883, Garbino 2016). Those expeditions aimed to record the Brazilian biodiversity and create scientific collections, with records of indigenous and immigrant perceptions of bats (Santos et al. 2007, Velden 2012, Garbino 2016). Until the beginning of the 20th century, studies with bats were limited due to the lack of a specific capture method, and only in 1968 did mist nets appear, facilitating the capture of bats (Kunz & Kurta 1998). From the 1970's, the researches have focused on reproductive biology, systematics, ecology, behavior and food habits of bats (Pacheco et al. 2009).

Despite of the progressive increasing in the knowledge of the Brazilian bat fauna, there is no information about its occurrence in approximately 60% of the national territory (Bernard et al. 2011). Also, Bernard et al. (2012) highlighted gaps on horizon analyses to identify topics on bat species conservation in Brazil. These gaps are important due to the country holds 13% of the global diversity of chiropterans, with 181 species with confirmed records (Nogueira et al. 2014; Garbino et al. 2020). Among the Brazilian biomes, the Amazon holds the greatest specific richness, followed by the Atlantic Forest, Cerrado, Caatinga, Pantanal and Pampa (see Paglia

et al. 2012). Due to the high diversity of bats, associated to the great territorial extension of Brazil and the alarming scenario of degradation of the Brazilian natural environments, it is necessary to have an integrated diagnosis on the knowledge produced till the present. A potential tool to this type of diagnosis is the scientometrics, as it assesses the organization of published data in indexed journals, allowing the mapping of scientific fields and the use of indicators by politicians and science menagers (Mingers & Leydesdorf 2015).

Specifically to the Brazilian bat fauna, few scientometrics analyses have already been carried out, but with other aims. Bernard et al. (2011) and Delgado-Jaramillo et al. (2020) showed the occurrence and distribution of Brazilian bats, analyzing the spatial performances of inventories in scientific papers. The same authors also identified the main factors to contribute to the recent increasing in the Brazilian bat fauna knowledge. Nevertheless, some important attributes to the scientific production were not analyzed, as poorly studied research fields, or which states hold the greatest volume of information and in which research fields. In this context, the aim of this scientometric study was to analyse the literature on bats in Brazil in order to identify patterns, tendencies and knowledge gaps to this animal group in the 26 federal states and one federal district (Brazilian political division) of Brazil.

MATERIAL AND METHODS

Data origin and search procedure

We obtained data in the databases ClarivateAnalytics Web of Science (WoS), ScientificElectronic Library Online (SciELO), PubMed, and Scopus. We included all the records characterized by the articles in journals or bibliographic revisions, published from 1954 (the year of the first published paper on bats in Brazil) and December 2018 in this study. We also included researches by the terms "Chiroptera" and "Brazil" in the tittles, abstracts and keywords. In two databases the research was carried out in the field "Advanced search", using the boolean operator "AND" between the terms. If the terms of the search were not present in the keywords, tittle or abstract, the indexed article was not included in our data. The term "bats" was not included in the search because all the papers including "bats" also included "Chiroptera". We tested the inclusion of this terms in the searches, however the number of papers did not increased. For this reason, we decided not include "bats" at this step. We extracted, from the articles, the year of publication, the regions and, when present, the Brazilian state where the study was carried out. After that, from the thematics approached, we classified the articles in 22 categories (Table I). Considering the broad delimitation of subjects, some articles were classified in two or more categories, being contabilized once in each category. Posteriorly, the data were saved in BibTex format (Aria & Cuccurullo 2017). Besides these databases, we manually included the data from the papers published in the Chiroptera Neotropical journal, that kept active from the year 1995 to 2015 and is not indexed in any of those databases. Inclusing this journal is justified by the important collection of bat studies in Brazil it contains.

The data obtained in the databases PubMed, SciELO, Scopus and WoS were pooled and after that, with the help of EndNote and the function "find duplicates", duplicated records were deleted. In a next step, to avoid the idiomatic conflict or text formatting, which could create problems in recognizing duplicated or studies not developed in Brazil, we carried out a manual selection, removing articles that did not match the criteria. To the articles of

Table I. Table with 22 thematic categories, respective acronyms and their delimitations, based on the approaches brought in the articles on bats, indexed in the Clarivate Analytics Web of Science (WoS), Scientific Electronic Library Online (SciELO), PubMed and Scopusdatabases, and in the non-indexed journal Chiroptera Neotropical, between the years 1954 and 2018 in Brazil.

CATEGORY	ACRONYMS	DELIMITATION
Reproductive biology	RB	Reproductive aspects and patterns
Composition and / or distribution	CD	Descriptions and records of distribution of bats assemblies
Conservation	CO	Studies focusing on protected areas, fragmentation effects, climate change.
Diet	DI	Food consumption records and nutritional patterns
Roost ecology	RE	Records, features and roost occupation descriptions
Ecolocation	EC	Identification, description of acoustic properties and monitoring
Road ecology	ROE	Road kill of species on highways
Epidemiology	EP	Epidemiological studies focusing on public health
Ethnozoology and/ or environmental education	ETN	Socio-environmental conceptions and representations about bats
Vertical structure	VS	Sampling in different forest platforms
Physiology, cytology and / or biochemistry	FCB	Biomolecular and microbiological studies
Genetics	GE	Analysis of karyotypes, DNA and evolutionary patterns
Environmental licensing	EL	Studies based on a sample of environmental licensing work, to assess the impact of the development bats.
Sampling method	SM	Characterization of the sampling and capture methods of chiropterans
Morphology	MO	Descriptions of the physical characteristics of the species
Palaeontology	PA	Fossil records and description of species in different geological ages
Parasites and / or associations	PAR	Parasites: endo and ectoparasites interacting with bats
Activity patterns	AP	Ecological patterns and influences on behavior
Movement patterns	MP	Distances in foraging
Predation	PRE	Bat predation records
Taxonomy, systematics and / or phylogeny	TSF	Description of new species and taxonomic, systematic and phylogenetic reviews
Habitat use	HU	Standards and ecological restrictions on the use of environments

Chiroptera Neotropical, there were no problems of duplicated, since the data were obtained manually.

RESULTS

A total of 1,638 papers was obtained from the databases, being 422 papers from PubMed, 173 from SciELO, 678 from Scopus and 365 from WoS. After cleaning for duplicates, it remained 896 papers. In the Chiroptera Neotropical journal, it was contabilized 219 papers, then, the total of 1,115 papers has been analyzed. It is important to highlight that 123 papers did not present any information that could determine the study area, being these deleted from the analysis for region or state, but kept in other categories.

The chronology of the bat studies in Brazil started in 1954, being the first indexed article approaching the "Epidemiology" category. The second article was published eight years later (1963), focusing on "Parasites and/or Associations". From the year of 1988 there is a constance in the publications, with at least one study per year. The year of 2010 stands out by the greatest number of articles, with 155 recorded papers, followed by 2017 with 103, 2015 with 108, 2014 with 107 and, at last, 2018 with 99. The other years followed the pattern of less than 100 articles /year (Figure 1).

Among the 22 analyzed categories, the "Composition of Assamblages and/or Distribution" (n = 461), "Epidemiology" (n = 241) and "Parasites and/or Associations" (n

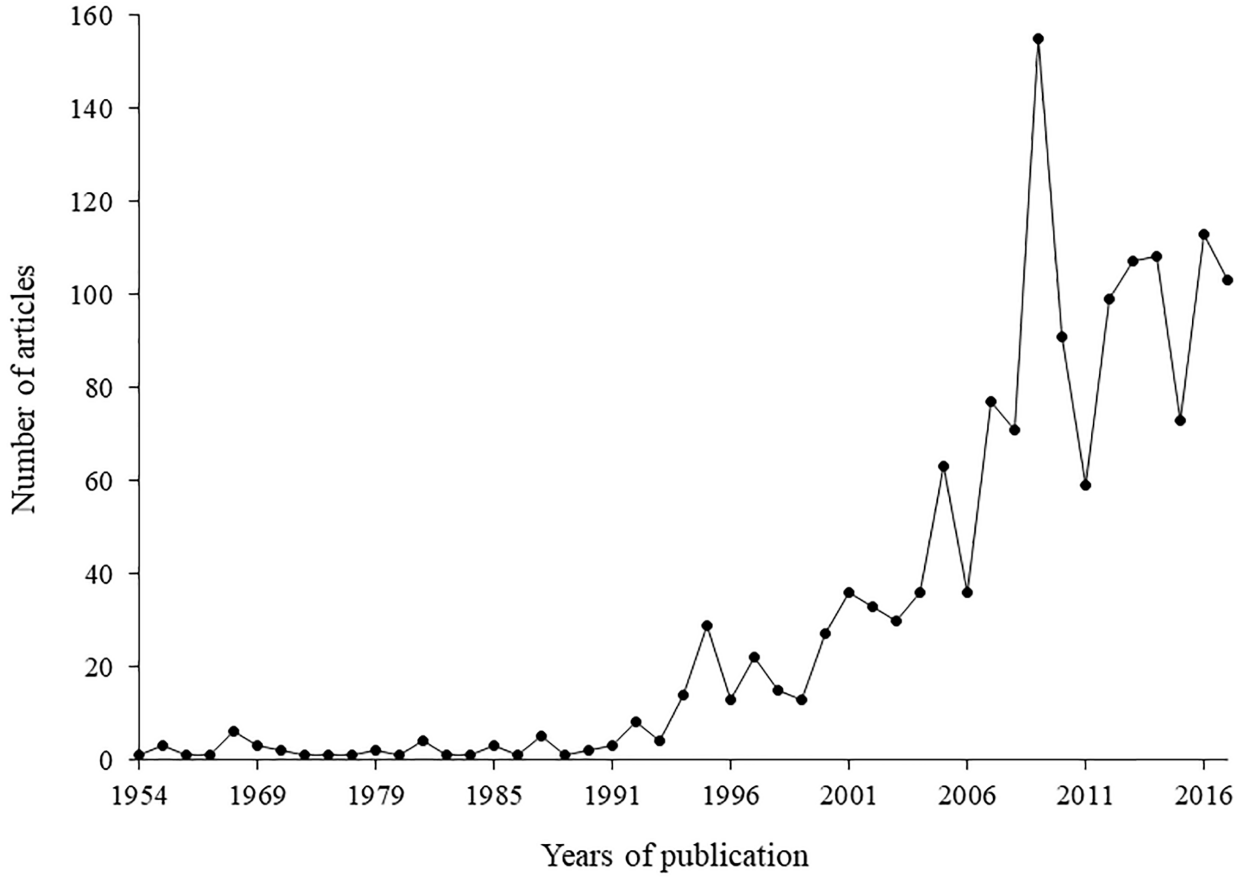

Figure 1. Graphical representation of the accumulation curve of the bat articles indexed in the Clarivate Analytics Web of Science (WoS), Scientific Electronic Library Online (SciELO), PubMed, Scopus, and in the non-indexed journal Chiroptera Neotropical, during the years 1954 to 2018, in Brazil.

= 213) were those with the greatest number of papers (Figure 2). On the other hand, the categories with the lowest number were "Movement Patterns" (n = 19), "Conservation" (n = 12), "Echolocalization" (n = 11), "Sampling Methods" (n = 8), "Paleontology" (n = 6), "Vertical Structure" (n = 4), "Environmental licensing" (n = 3), "Ethnozoology and/ or environmental education" (n = 3) and "Road Ecology" (n = 2) (Figure 2).

The Southeast region held the highest number of articles (n = 518), with the other regions presenting equated numbers (Table II). By region, the category "Composition of Assamblages and/or Distribution" was that with the greatest number of articles (Southeast = 132, Northeast = 110, North and South = 66 each, and Midwest = 64) (Table II). The second category with the greatest number of articles differed among regions, being the category "Epidemiology" for Southest, North and Northeast (99, 44 e 39, respectively). However, "Parasites and/ or Associations" was in second place for the Midwest and South (32 and 29, respectively - Table II).

DISCUSSION

Studies on bats in Brazil correspond to a recent research field with the first indexed article dating from 66 years ago (Carneiro 1954, Deane & Sugay 1963). Despite of it, Brazil occupies the fourth place in number of indexed articles, being the countries of the United States of America, Germany and United Kingdom the greatest contributors (Scopus 2020). The beginning of bat publications in these countries are similar to ours, but with a greatest frequency of publications since the 1960's. However, each country has a unique development. The USA, for example, had already 24 indexed articles in 1974, while Brazil had 24 in the year of 1996.

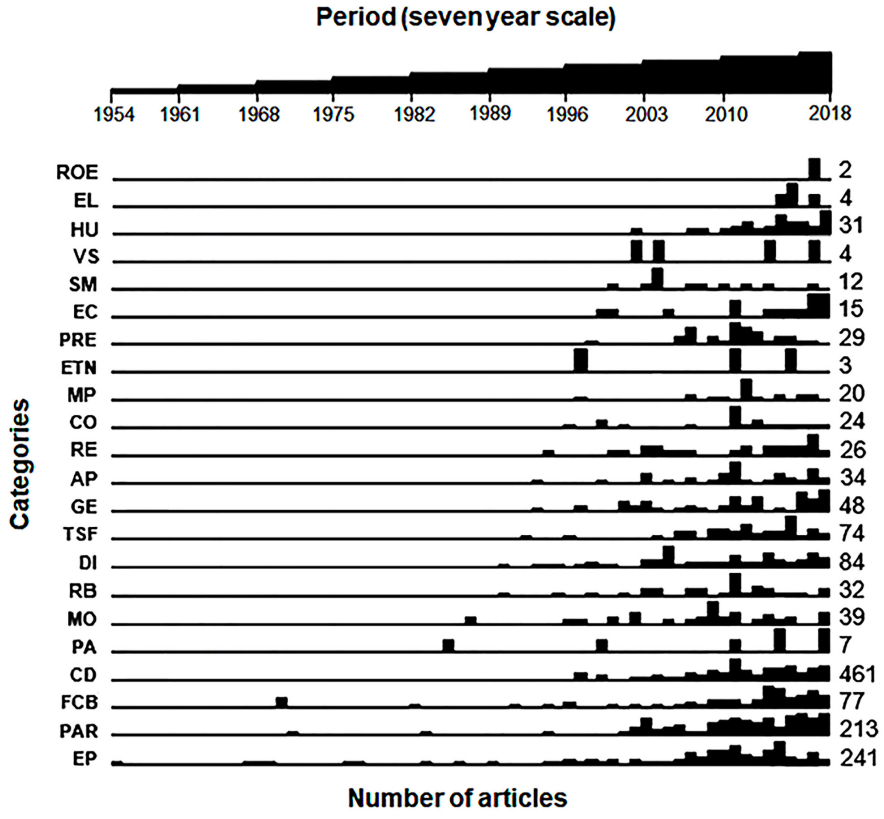

Figure 2. Graphical representation of the total values of the 22 thematic categories on bat articles and with the numbers of publications between the years 1954 to 2018 in Brazil, indexed in the Clarivate Analytics Web of Science (WoS), Scientific Electronic Library Online (SciELO), PubMed, Scopus, and in the non-indexed journal Chiroptera Neotropical. For consultation of the acronyms see Table I.

In this same year, the USA reached 51 articles (Scopus 2020). The year average of publications from Brazil was 23.1 articles/year and only from the 2000's that the country reached a number greater than the national average. It should be noted that this panorama would be different if annals and abstracts of national and international congresses, as well as master and doctoral thesis were included, once they make up about 60% of the means to disseminate scientific researches on bats in the national territory (Pacheco et al. 2009).

The deficit of publications in Brazil might be explained by a set of reasons, as the lack of funding in scientific research, in post graduation programs and fellowships. The funding to these fields had an increasing in the 2000's and after, in the year of 2004, even with no constant public

Table II. Table with the total values of the 22 thematic categories on bat articles by Brazilian regions and federal states, indexed in the Clarivate Analytics Web of Science (WoS), Scientific Electronic Library Online (SciELO), PubMed and Scopus databases and non-indexed journal Chiroptera Neotropical, between 1954 and 2018 in Brazil. Where: Total number (T), Acre (AC), Alagoas (AL), Amapá (AP), Amazonas (AM), Bahia (BA), Ceará (CE), Distrito Federal (DF), Espírito Santo (ES), Goiás (GO), Maranhão (MA), Mato Grosso (MT), Mato Grosso do Sul (MS), Minas Gerais (MG), Pará (PA), Paraíba (PB), Paraná (PR), Pernambuco (PE), Piauí (PI), Rio de Janeiro (RJ), Rio Grande do Norte (RN), Rio Grande do Sul (RS), Rondônia (RO), Roraima (RR), Santa Catarina (SC), São Paulo (SP), Sergipe (SE), Tocantins (TO). For consultation of the acronyms see Table I.

Acronyms	BRASILIAN GEOGRAPHIC REGIONS																														
	MIDWEST					NORTHEAST										NORTH								SOUTHEAST					SOUTH			
	DF	GO	MS	MT	T	AL	BA	CE	MA	PB	PE	PI	RN	SE	T	AC	AM	AP	PA	RO	RR	TO	T	ES	MG	RJ	SP	T	PR	RS	SC	T
RB	1	1			2			1			2				3		1						**1**	1	4	10	3	**18**	7	1		8
CD	3	10	25	26	**64**	5	20	11	6	17	14	9	7	21	**110**	3	15	8	17	13		10	**66**	17	43	47	25	**132**	36	19	11	**66**
CO		1	1	1	**3**		1					1			2									1	1	2	1	**5**	1	1		2
DI	2	1	6		9		2				4		3	3	**12**		5		1				**6**	6	6	7	13	**32**	15	3	3	**21**
RE	1				1		2				2		1		5		2		1				3				2	**2**				
EC	1		2		3						1		1		2		3						**3**	1	2	7	6	**16**				
ROE																										1		1			1	**1**
EP	3	5	7	7	**22**		6	2	13	6	6		2	1	**36**	3	6	2	20	5	1	7	**44**	3	15	8	73	**99**	7	5	4	**16**
ETN																	3						3								1	**1**
VS										1	1				2											1		1				
FCB	4	1		2	**7**			1			3		1	3	**8**		1					1	2		21	5	25	**51**	1		2	**3**
GE			1	1	**2**		3			1	8		1		13		3		10				13		3	2	2	**7**		1	1	**2**
EL							1								1					1			1							1		1
SM																	1						1		1	4	1	**6**			1	**1**
MO	3		1		4			2			3			1	**6**				1			1	**2**		4	3	5	**12**	3	5	2	**10**
PA	3			1	**4**					1	1		1		**3**	1	4		2				7		4	8	2	**14**	6			6
PAR														1	**1**			1					**1**	2	2	5	2	**11**	4	1	1	**6**
AP							4					1			5															1		1
MP	8	4	15	5	**32**		7	7	4	1	5	3	3	4	**34**	3	6	1	10	9	1	3	**33**	4	17	23	25	**69**	14	13	2	**29**
PRE			3	2	**5**												1	2	1				**4**	2	3	4	5	**14**	4	2		6
TSF	1	1	2	2	**6**		5	3		4	6	1		1	**20**		3	2	6	1			**12**	3	3	5	6	**17**	6	3	2	**11**
HU	2	1	1	2	**6**		1				1			1	**3**		4		2				**6**	4	2	2	3	**11**	1	1		2
State	32	25	64	49		5	52	27	23	31	57	15	20	36		10	58	16	71	29	2	22		44	131	144	199		105	57	31	
Region	170					266										208								518					193			

budget for science (Cruz 2007, Leite et al. 2011, Helene & Ribeiro 2011). Between the years of 1998 and 2011, Cirani et al. (2015) observed an increasing in post graduation programs sensu strictu in Brazil, but concentrated in Southern and Southeast regions of the country, evidencing regional inequalities that influences directly the scientific and technological production in Brazil, as well as the perspectives of regional knowledge.

The fellowships granted by the Coordination for the Improvement of Higher Education Personnel (CAPES) and state research support foundations (FAPs) and private institutions have been stimulating the training and renewal of Brazilian researchers (Santos & Azevedo 2009). However, in the New Scholarship Award Model from CAPES, published last year (2020), the assymetry of scientific knowledge is likely to increase, due to the impossibility of new post graduation programs to compete with well stablished ones, and consequently, with better grades in the CAPES's four-year evaluation (Oliveira et al. 2020, Reis et al. 2020).

The access of new technologies, the creation of specialized scientific communities and the rise of information systems for academic purposes in the year of 2004 resulted in an advance in the access to publications and, consequently, facilitated the development of new studies (Beira 2010). However, this scenario is retrating. In 2013, Brazil recorded a peak in STEM's investiments, compared to the years after 2003, and in 2020 the funds were reduced for 55.04% of the budget (Reis & Macário 2020, Reis et al. 2020). The political instability of public investiments in the national science impars its consolidation and limits the development of new studies from many knowledge areas.

For bats, the categories with the greatest number of published studies until 2018 coincide with those of the first publications in Brazil, with the papers on composition of assemblages and distribution, parasitology and epidemiology being the most abundant (Pine et al. 1970, Carneiro 1954, Deane & Sugay 1963, Pedroso et al. 2018, De Souza et al. 2018, Sabino-Santos et al. 2018). Although the category of composition of assemblages and/or distribution was only explored 16 years after the first published article in Brazil, it is currently the one with the largest number of studies in all five Brazilian regions. It can be explained by the increase in studies describing diversity patterns.

Understanding the spatial distribution of species is an old concern of scientists, who had investigated patterns of diversity and distribution, and seen this data starting to support bat management and conservation actions (Delgado-Jaramillo et al. 2020). In this perspective, studies with a focus or that subsidize information on the composition of bat communities are still necessary, despite representing the category with the greatest number of studies. This importance is reinforced considering that for 60% of the national territory there is still no information on the occurrence of bats (Bernard et al. 2011, Delgado-Jaramillo et al. 2020).

Due to its high diversity of bat species in Brazil, many regions are considered undersampled, even in areas with high sampling effort, as in the southern portion of the Atlantic Forest (Varzinczak et al. 2015, Ramírez-Chaves & Castro 2017). The high number of studies on the assamblage composition is observed in all regions, what suggests the incidence of a decriptive process of the bat faunas, due to this be a recent research field.

The second category with the largest number of articles is epidemiology, which may be associated with the interest in bats as reservoirs of pathogens – the same that can cause economic and public health problems.

Although more than 200 zoonotic viruses have already been isolated or detected in bats, the supposed connections between these animals, viruses and human diseases have been raised more by speculation than by scientific evidence, with the exception of rabies (Moratelli & Calisher 2015). A recent example was the association of bats as the origin of the new coronavirus (SARS-CoV-2), the virus that causes the COVID-19 pandemic, which is still uncertain, as this virus showed 91.02% of the genome similarity to 2019-nCoV, which was found in pangolins (Zhang et al. 2020). Most likely, after 2019, we will have an increase in the number of papers on this topic. Considering bats' high flight capacity, the odds of transmitting infectious agents among species are high (Wong et al. 2019). It reinforces the importance of long-term studies with epidemiological and parasitic approaches in all regions of Brazil.

In the category of parasites and/or associations, which had third place in number of studies, we observed the dominance of studies focusing on ectoparasites. There are few studies focusing on endoparasites (Lainson & Naiff 2000, Mourão et al. 2002, Noronha et al. 2002). The same is observed for associations with fungi, with only seven studies (Mok et al. 1982, Peçanha Martins et al. 2000, Cordeiro et al. 2012, Taylor et al. 2012, Cavallini Sanches et al. 2013, Zórtea et al. 2015, Brilhante et al. 2016). Considering that one of the main threats to bat conservation is related to fungi (Lorch et al. 2011), it must be one of the priority research fields in Brazil. Understanding the interaction among fungi and bats is essential for the control and prevention of diseases that can threat chiropterans (Hoyt et al. 2020).

On the opposite, the categories with the largest number of studies (Road Ecology, Vertical Structure, Ethnozoology and/ or environmental education, Environmental Licensing, Sampling Method and Paleontology) represent together only 1.9% of the studies. Bernard et al. (2012) described topics that must receive attention for chiropterans conservation in Brazil, which address questions about anthropological and epidemiological risks, protection of roosts, environmental and ecological education, physiological and molecular knowledge applied to conservation, gaps in geographic distribution, conservation and monitoring of species, scarcity of investments in museums and scientific collections, as well as in professionals specialized in systematics and taxonomy. In order to advance in the knowledge and conservation of bats in the country, all these themes constituted the priority for carrying out studies throughout the Brazilian territory.

It was observed that the Southeast region stands out with the highest number of articles, holding 38.14% alone. In contrast, the Midwest region has the lowest number of articles with 12.52%. Several reasons contribute to this panorama, from the historical efforts' concentration near or around specific cities and research centers to logistical obstacles to poorly accessible places (Garbino 2016, Delgado-Jaramillo et al. 2020). The better detailing of knowledge in the Southeast can be explained by the history of zoological research carried out by large research institutions, associated with a greater concentration of researchers, traditional scientific institutions and important zoological collections, mainly in São Paulo and Rio de Janeiro cities (Pacheco et al. 2009, Garbino 2016, Delgado-Jaramillo et al. 2020). Nevertheless, there is also a disparity between the states that make up the Southeast region, since the state of Espírito Santo presents only 44 articles, which demonstrates that no region can be considered as well studied.

Analyzing some regions and federal states, the panorama is even more concerning. For

example, in the North, Roraima State has only two articles and none focusing on biodiversity. In the Northeast, the state of Alagoas has only five studies, all in the inventory category. The South region has an equally disproportionate scenario, where Paraná holds 54% of publications, while Rio Grande do Sul and Santa Catarina hold 30% and 16%, respectively.

It is possible to observe that each region and Brazilian state has particularities in their publications and gaps of studies with chiropterans, not being possible to generalize the panorama by federal regions. Identifying the approaches and the number of publications in each of them becomes an important tool to direct future efforts on bats in Brazilian states (Bernard et al. 2012, Delgado-Jaramillo et al. 2020). Regardless of the number of articles by categories, we reinforce the need for all approaches to continue being developed, whereas no theme can be considered sufficiently explored. We hope that the panorama presented here will be used to guide future research in the different regions, and that we will be able to fill the gaps that exist today soon.

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REFERENCES

ARIA M & CUCCURULLO C. 2017. Bibliometrix: An R-tool for comprehensive Science mapping analysis. J Inf 11(4): 959-975.

BEIRA EJC. 2010. Inovação e concorrência em serviços de informação académica: de Eugene Garfield ao Google Scholar. Encontros Bibli: Rev Eletro Biblio Ciê Infor 15: 132-163.

BERNARD E, AGUIAR LMS & MACHADO RB. 2011. Discovering the Brazilian bat fauna: a task for two centuries? Mammal Review 41(1): 23-39.

BERNARD E, AGUIAR LMS, BRITO D, CRUZ-NETO AP, GREGORIN R, MACHADO RB, OPREA M, PAGLIA AP & TAVARES VC. 2012. Uma análise de horizontes sobre a conservação de morcegos no Brasil. In: Freitas TRO & Vieira EM (Eds), Mamíferos do Brasil: Genética, Sistemática, Ecologia e Conservação. Rio de Janeiro: Sociedade Brasileira de Mastozoologia, p. 19-35.

BRILHANTE RS ET AL. 2016. Yeasts from the microbiota of bats: a focus on the identification and antimicrobial susceptibility of cryptic species of *Candida*. J Med Micro 65(10): 64-47.

CARNEIRO V. 1954. Transmission of rabies by bats in Latin America. Bull Wor Hea Org 10(5): 775-780.

CAVALLINI SANCHES EM, FERREIRO L, ANDRADE CP, PACHECO SM, ALMEIDA LL, SPANAMBERG A & WISSMANN G. 2013. *Pneumocystis* sp. in bats evaluated by qPCR. J Mycol Med 23(1): 47-52.

CIRANI CBS, CAMPANARIO MA & SILVA HHM. 2015. A evolução do ensino da pós-graduação senso estrito no Brasil: análise exploratória e proposições para pesquisa. Avaliação 20: 163-187.

CORDEIRO RA ET AL. 2012. *Coccidioides posadasii* infection in bats, Brazil. Emerg Infect Dis 18(4): 668-670.

CRUZ CHB. 2007. Ciência e tecnologia no Brasil. Rev USP 73: 58-90.

DE SOUZA WM ET AL. 2018. Discovery of novel anelloviruses in small mammals expands the host range and diversity of the Anelloviridae. Virology 524: 9-17.

DEANE LM & SUGAY W. 1963. *Trypanosoma pessoai* n. sp., in vampire bats *Desmodus rotundus* from the state of São Paulo, Brazil. Rev Inst Med Trop SP 5: 165-169.

DELGADO-JARAMILLO M, AGUIAR LMS, MACHADO RB & BERNARD E. 2020. Assessing the distribution of a species-rich group in a continental-sized megadiverse ountry: Bats in Brazil. Diver Distri 00: 1-12.

GARBINO GST, GREGORIN R, LIMA IP, LOUREIRO L, MORAS LM, MORATELLI R, NOGUEIRA MR, PAVAN AC, TAVARES VC & PERACCHI AL. 2020. Updated checklist bats of Brazilian. Comitê da Lista de Morcegos do Brasil/Sociedade Brasileira para o Estudo de Quirópteros. Available in: https://www.sbeq.net/lista-de-especies. Access in: 20 November 2020.

GARBINO STG. 2016. Research on bats (Chiroptera) from the state of Sao Paulo, southeastern Brazil: annotated

species list and bibliographic review. Arq Zoo 47(3): 43-128.

HELENE AF & RIBEIRO PL. 2011. Brazilian scientific production, financial support, established investigators and doctoral graduates. Scientometrics 89: 677-686.

HOYT JR ET AL. 2020. Environmental reservoir dynamics predict global infection patterns and population impacts for the fungal disease white-nose syndrome. Proc Nat Acad Sci USA 117(3): 7255-7262.

KUNZ TH & KURTA A. 1998. Capture Methods and Holding Devices. In: Kunz TH (Ed), Ecological and Behavioral Methods for the Study of Bats. Washington: Smith Inst Press, p. 130.

LAINSON R & NAIFF RD. 2000. On *Eimeria bragancaensis* n. sp. (Apicomplexa: Eimeriidae) and tissue-cystsofanun identified protozoan in the bat *Peropteryx macrotis* (Chiroptera: Emballonuridae) from Amazonian Brazil. Parasite 7(2): 123-129.

LEITE P, MUGNAINI R & LETA J. 2011. A new indicator for international visibility: exploring Brazilian scientific community. Scientometrics 88: 311-319.

LORCH JM ET AL. 2011. Experimental infection of bats with *Geomyces destructans* causes white-nose syndrome. Nature 480: 376-379.

MINGERS J & LEYDESDORFF L. 2015. A review of theory and practice in scientometrics. Euro J Ope Res 246: 1-19.

MOK WY, LUIZAO RC & BARRETO DA SILVA MDOS. 1982. Isolation of fungi from bats of the Amazon basin. Appl Env Micro 44(3): 570-575.

MORATELLI R & CALISHER CH. 2015. Bats and zoonotic viruses: can we confidently link bats with emerging deadly viruses?.Mem Inst Oswaldo Cruz 110(1): 1-22.

MOURÃO ED, AVILLA LDS & LENT H. 2002. Redescription of *Litomosoides brasiliensis* Almeida 1936 (Nematoda: Filariiidae) from a new host *Anoura caudifer* (Chiroptera: Phyllostomidae). Mem Inst Oswaldo Cruz 97(4): 495-499.

NOGUEIRA MR, LIMA IP, MORATELLI R, TAVARES VC, GREGORIN R & PERACCHI AL. 2014. Checklist of Brazilian bats, with comments on original records. Check List 10(4): 808-821.

NORONHA D, VICENTE JJ & PINTO RM. 2002. A surveyof new host records for nematodes from mammals deposited in the Helminthological Collection of the Oswaldo Cruz Institute (CHIOC). Rev Bra Zoo 19(3): 945-949.

OLIVEIRA EA, MARTELLI JÚNIOR H, SILVA ANS, MARTELLI DRB & OLIVEIRA MCL. 2020. Science funding crisis in Brazil and COVID-19: deleterious impact on scientific output. An Acad Bras Cienc 92: e20200700. https://doi.org/10.1590/0001-3765202020200700.

PACHECO SM, SODRÉ MM, MELLO ARM, MARQUES RV, UIEDA W, AGUIAR L, PASSOS FC, TRAJANO E & BREDT A. 2009. Chiropeta. In: Rocha RM & Boeger WAP (Eds), Zoologia no Brasil. Estado da Arte e Perspectivas. Paraná: Editora UFPR, p. 248-266.

PAGLIA AP ET AL. 2012. Lista Anotada dos Mamíferos do Brasil. Occa Pap in Conserv Bio 6: 1-76.

PEÇANHA MARTINS AC, COSTA NEVES ML, LOPES AA, QUERINO SANTOS NN, ARAÚJO NN & PEREIRA KM. 2000. Histoplasmosis presenting as acute respiratory distress syndrome after exposure to bat feces in a home basement. Braz J Inf Dise 4(2): 6-103.

PEDROSO MA, DA ROCHA PA, BRANDÃO MV, GARBINO GST & DE MORAES CO. 2018. Filling gaps in the distribution of the white-winged vampire bat, *Diaemus youngii* (Phyllostomidae, Desmodontinae): new records for southern Amazonia. Acta Amazonica 48(2): 154-157.

PINE RH, BISHOP IR & JACKSON RL. 1970. Appendix preliminary list of mammals of the Xavantina/Cachimbo expedition (Central Brazil). Trans Roy Soc Trop Med Hyg 64(5): 668-670.

RAMÍREZ-CHAVES HE & CASTRO AFS. 2017. Lista de referência de espécies de mamíferos de Colômbia, Conjunto de datos/Lista de espécies. Soc Colom de Masto Versión 1.2.

REIS AC, BLUNDI BAS & SILVA EP. 2020. O desmantelamento da ciência brasileira no deliberado corte de bolsas: aspectos políticos e consequências psicossociais para estudantes de pós-graduação. Muiraquitã 8: 371-393.

REIS LF & MACÁRIO E. 2020. Public debt and financing of federal universities and science and technology in Brazil (2003-2020). Práxis Educacional 41: 20-46.

SABINO-SANTOS G ET AL. 2018. Natural infection of Neotropical bats with Hantavirus in Brazil. Scientific Reports 8: 1-8.

SANTOS ALF & AZEVEDO JML. 2009. A pós-graduação no Brasil, a pesquisa em educação e os estudos sobre a política educacional: os contornos da constituição de um campo acadêmico. Rev Bras Educ 42(14): 534-605.

SANTOS CFM, FERREIRA VS & CARREIRA L. 2007. Os quirópteros do Novo Mundo a América e o morcego hematófago no relato de viajantes quinhentistas. Var Hist 23(38): 561-573.

SCOPUS. 2020. Search for articles by the terms "Chiroptera" and "Bat". Resource document. Elsevier Scopus: https://www.scopus.com/term/analyzer.uri?sid=247b50672ba34bfe479037ebe6ca3fa5&origin=result

slist&src=s&s=TITLE-ABS-KEY%28%22chiroptera%22+AND+%22bat%22%29+AND+PUBYEAR+%3e+1936+AND+PUBYEAR+%3c+1999&sort=plf-f&sdt=cl&sot=b&sl=75&count=1002&analyzeResults=Analyze+results&cluster=scoaffilctry%2c%22United+States%22%2ct&txGid=4d3e407e3e9f5dddfc8f6ebec72c00cd. Accessed 23 June 2020.

TAYLOR ML ET AL. 2012. Genetic diversity of *Histoplasma capsulatum* isolated from infected bats randomly captured in Mexico, Brazil, and Argentina, using the polymorphism of (GA) microsatellite and its flanking Regions. Fungal Bio 116 (2): 308-317.

VARZINCZAK LH, BERNARDI IP & PASSOS FC. 2015. Is the knowledge of at distribution in the Atlantic Rainforest sufficient? Comments about new findings and a case study in the Paraná State coastal area, Brazil. Mammalia: 1-7.

VELDEN FFV. 2012. As galinhas incontáveis. Tupis, europeus e aves domésticas na conquista no Brasil. J Soci Améric 98(2): 97-140.

VON PELZELN A. 1883. *Brasiliche Säugethiere*. Resultate von Johann Natterer'sReisen in den Jahren 1817 bis 1835. K.K. Zoo-Bot Ges 33: 1-140.

WONG ACP, LI X, LAU SKP & WOO PCY. 2019. Global Epidemiology of Bat Coronaviruses. Viruses 174(11): 1-17.

ZHANG T, WU Q & ZHANG Z. 2020. Pangolin homology associated with 2019-nCoV. Current Bio 30: 1346-1351.

ZÓRTEA M, BASTOS NA & ACIOLI TC. 2015. The bat fauna of the Kararao and Kararao Novo caves in the area under the influence of the Belo Monte hydroelectric dam, in Para, Brazil. Braz J Biol 75(3): 168-173.

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